ontario hydro
research division

To: Dr. D. Mills
Director of Research

CORROSION AND TRITIUM TECHNOLOGY SECTION
1988 REVIEW AND 1989 WORK PROGRAM

P.C. Lichtenberger

The key projects and achievements of the Corrosion and Tritium Technology Section (C&TT) during 1988 are reviewed and the work program for 1989 is highlighted. The section activities are concentrated largely in the areas of Zr alloy corrosion/hydrogen ingress mechanisms, steam generator/heat exchanger corrosion mechanisms, tritium handling/storage processes, and tritium interactions with metals.

INTRODUCTION

This report presents an overview of the C&TT Section work programs, the key progress achieved during 1988, and the direction in which the work program will be focused in 1989.

The mission of the section is to carry out R&D, perform technical investigations and act as a corporate centre for expertise in the areas of metallic corrosion mechanisms/control, and tritium-metal interactions/tritium handling. The section is accordingly divided into two main work groups - Corrosion (60%) and Tritium Technology (40%).

Corrosion

Pressure tube Zr alloy corrosion and hydrogen ingress mechanisms work is high priority accounting for 30% of the section's efforts. The critical need is to understand these processes so that reliable predictions of current pressure tube life can be made, and also so that improved materials and/or operating procedures can be established to extend the life of these components. Research is concentrated on heat transport system coolant effects, alloy microchemical/microstructural effects, and annulus gas effects.

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Nuclear Steam Generator tubing corrosion mechanism research is also a key activity accounting for 15% of the section's efforts. Despite the world class record of performance reliability, there remain concerns as to the long term integrity of this tubing. Anticipatory research is being concentrated in the areas of stress corrosion cracking, corrosion fatigue, and under deposit localized corrosion degradation. Generic degradation of this kind has led to large incapability in nuclear steam generating equipment around the world.

As a result of failures in a number of nuclear plant heat exchangers, a substantial research effort is in progress to quantify under-deposit pitting and other local corrosion degradation mechanisms. This work accounts for roughly 10% of section activity. Work is focused on establishing the role of alloy chemistry and microchemistry, microbiology, and deposit formation. Electrochemical techniques and high sensitivity surface analysis methods combined with laboratory and site exposure test rigs, form the basis of these activities.

The remaining 5% of activities in the corrosion program involve corrosion engineering support to nuclear, thermal, and hydraulic plant equipment, as well as transmission, distribution and other related equipment. The main efforts here are directed toward corrosion failure evaluation, corrosion control methods, corrosion monitoring, and selection/evaluation of materials to reduce or eliminate corrosion. Despite the proportionately smaller activity effort here, this application of expert corrosion advice provides large cost benefit ratios, often exceeding a factor of 10 and more.

Tritium Technology

The Tritium Technology (TT) group was formed in 1987 by the amalgamation of two separate work groups within the Section. Engineers responsible for the design and construction of the Tritium Immobilization System (TIS) for the Darlington NGS Tritium Removal Facility (TRF) were combined with the scientists responsible for tritium research in support of fission and fusion applications.

A main component of this work involves metal getter research and development, which accounts for about 15% of the section work activity. Getters are an extremely safe and effective way of storing and immobilizing large volumes of hydrogen isotopes. This work directly supports Darlington TRF. Activities involve characterization/ quantification of getter properties and kinetics. This work is resulting in the development of practical and efficient storage and recovery devices with commercial applications.

The study of tritium interactions with materials, accounts for another 10% of section effort. Hydrogen isotopes due to their small atomic volume and mass, rapidly permeate through most engineering materials. Add to this the emission of an energetic beta particle (resulting from the decay of the tritium atom) and there exists the potential for progressive material property degradation. Understanding these

progressive material property degradation. Understanding these processes is crucial to understanding tritium effects in fission and potential fusion material processes. Both applied and basic work is investigating the consequences of material degradation as well as unique gas separation/filtering methods.

In order to study tritium materials interactions, gas handling systems/processes are required. The development of these facilities accounts for the final 15% of the section work program. A divisional tritium laboratory is now in operation. Direct support in commissioning and operating the tritium immobilization system of the Darlington Tritium Removal Plant and the design/construction of a tritium dispensing loop (TAP) is being provided.

Funding/Clients/Staffing

In 1988, the 3M$ work program of the C&TT section was roughly 70% transfer funded. By far the bulk of the work was in the Nuclear Generation program area with principal clients being Technical and Training Services Division, Nuclear Generation Division, and Design and Development Division. Work, performed on behalf of the CANDU Owners Group (COG) accounted for over 80% of all corrosion related transfer funds and for 1989, the figure is 90%. This large proportion of committed work is having a significant impact in terms of our ability to respond to short term corrosion work requests from other clients. Transfer funding of the Tritium Technology program accounts for about 60% of the total program costs. Four main client groups, the Canadian Fusion Fuels Technology Program (CFFTP), New Business Ventures Division (NBV), the Darlington Project, and the National Fusion Program, share the total effort.

The staff of the Corrosion and Tritium Technology Section are listed in Table 1. During 1988, three additional researchers were temporarily attached to the Tritium Technology group: two from CFFTP, and a University of Toronto Masters Student. Internal reports and external publications/presentations, visits and visitors are also attached. The following sections provide highlights of the key activities of the work program in terms of significant 1988 progress and planned objectives for 1989.

CORROSION PROGRAM

Zirconium Corrosion

Deuterium concentration in the body of CANDU Zr-2.5 wt% Nb pressure tubes (PTs) increases with operating time. Removed and/or scraped PTs from Pickering and Bruce reactors have shown highly variable levels of deuterium with a few tubes containing levels of sufficient magnitude to be of concern.

acts as an extremely effective diffusional barrier to the rate of uptake of deuterium. The sources of deuterium, which may be picked up by the PTs are: (i) the reactor coolant as a result of corrosion reactions (ID of the tube), and (ii) the annulus gas system (OD of the tube) a result of deuterium impurities in the gas supply as well as diffusion of deuterium from the coolant through end fittings.

Research programs fall into 4 major areas:

a) Out-reactor aqueous exposures are in progress to investigate deuterium/hydrogen and oxygen uptake in Zr-2.5 wt% Nb and Zircaloy-2 as a function of material, temperature, and exposure time.

Zr-2.5 wt% Nb exposed at 310°C and 250°C has to date, following 460 days exposure, displayed a normal pre- and post-transition behaviour without evidence of acceleration. Some evidence of acceleration in corrosion rate after 150-200 days exposure has been observed at 360°C. For Zr-2.5 wt% Nb samples with a similar smooth surface finish, and a range of iron contents between 400 and 1350 ppm, oxidation performance improved with increasing iron content. Deuterium concentrations generally increased proportionately with increasing weight gain with <5% of the deuterium produced by the corrosion reaction being absorbed. This work will continue in 1989 to longer exposures to further establish the kinetics of the corrosion and deuterium uptake processes.

b) Out-Reactor gaseous exposures are also in progress to investigate reaction mechanisms of D_2 and O_2 with Zr-2.5 wt% Nb in simuluated annulus gas environments and to develop kinetic behaviour (reaction rates) as a function of variables such as temperature (250-320°C), and surface composition. This work also includes oxide degradation and repair as a function of variables such as temperature, gas composition (O_2 and D_2), material condition, and time. To date progress has involved setting up of ultra-high vacuum equipment with a mass spectrometer and gas dosing system. During 1989, the experimental program will be initiated.

3. Characterization of near-surface chemical and microstructural changes occurring in PTs following in-reactor exposures is underway. Deuterium concentration profiles within inside and outside surface oxides in PT samples removed from P3L09, F13 and J09 (inlet and outlet regions) have been determined using the Secondary Ion Mass Spectrometry (SIMS) technique. For outside surface oxides, along the length of most removed reactor PTs, the deuterium concentration profiles show a steep gradient throughout, implying that the entire oxide is acting as a diffusional barrier to deuterium. In PT P3L09 however, a flat and high deuterium concentration profile throughout the oxide thickness, is found. Thus, there is a possibility that high levels of deuterium in the outside surface oxides of L09 arose as a result of the reduced

effectiveness of the oxide as a diffusional barrier. Consequently, the bulk deuterium uptake rate in this PT may have increased locally producing the observed peaks in axial deuterium concentration profiles. In 1989 additional microstructural/microchemical oxide analyses on a number of removed reactor PTs will be completed in the hope of further correlating similar features with deuterium found in the bulk alloy.

d) The final area of work involves modelling corrosion and deuterium uptake in Zr-2.5 wt% Nb pressure tubes. The objective of this work is to maintain a data base for removed/scraped pressure tubes from power reactors and for coupon exposures from in- and out-reactor experimental programs. The data is analyzed to help deduce an understanding to permit reliable predictions of corrosion and deuterium uptake in operating reactor pressure tubes.

Work continues to develop an explanation for the development of pronounced peaks in deuterium concentration profiles at pressure tube outlets in a few PTs. Peaks or the tentative beginnings of peak formation in axial deuterium concentration profiles have now been observed in outlet regions of P3D19 and B2L08 and S04 in addition to P3L09 and P4K10 (and P1 and P2 Zircaloy 2 pressure tubes). These peaks appear to correlate with the shape of the flux profile. An analytical model of (ϕ,T) has been postulated in terms of the competition between oxide degradation and microstructural evolution/surface reaction rate terms which seems to describe qualitatively the differences in peak shapes and corresponding locations observed for the most pronounced peaks seen to date. In 1989 this work will be extended by attempting to quantify the relationships between curve fitting parameters and postulated deuterium ingress processes.

Stress Corrosion Cracking of Steam Generator Tubing Alloys

Stress corrosion cracking of N06600 (alloy 600) tubing has proven to be a major reliability problem in PWR steam generators. Based on this and extrapolation of available research data, it is estimated that cracking of CANDU steam generator material could begin to become a problem after 15 years of operation. Although only 1 operational failure of N08800 (alloy 800) has been reported, cracking resistance of this alloy may be less than that of N06600 in certain environments, particularly very strong caustics.

This project was initiated to determine the low temperature stress corrosion cracking resistance of CANDU steam generator tubing alloys N06600 and N08800. To do this, samples of steam generator tubing with simulated process heat treatments are stressed and exposed at steam generator temperatures. Aggressive (high pH) environments are employed to produce results in a reasonable time. The main variable in testing is temperature.

Heat treatment and initial metallographic assessment of CANDU N06600 tubing was completed in 1987. Several autoclave tests in 350°C caustic solutions were completed in 1988, with durations of up to 2000 hours. Included in these exposures were various heat treatments of CANDU N06600, two lots of PWR tubing received from EPRI (high and low susceptibility heat treatments), and N08800.

A summary of results obtained in 1988 appears in the table following. Indicated is the relative cracking resistance based on preliminary maximum crack depth measurements from exposures to 10% NaOH at 350°C, for up to 2000 hours.

The table shows that as-received CANDU tubing is somewhat more resistant to cracking than the susceptible EPRI tubing and that tubes with tubesheet or full vessel heat treatments are considerably more resistant.

In 1989, autoclave testing will continue with exposures of 3000 and 4000 hours, at temperatures of 290 and 260°C. Extensive cracking measurements will be made and methods will be investigated to improve measurement efficiency.

Also in 1989, additional microstructural and microchemical information will be obtained on the alloys under study using a high voltage analytical electron microscope. This information will assist in understanding the observed differences in cracking resistance.

ALLOY	*SAMPLE CONDITION*	*DUAL-ETCH RESULT*	*ESTIMATED CRACK RESISTANCE (RELATIVE TO LOT 2)*
N06600	CANDU	Poor	2
	+500°C/10 Hr (BAU)	Poor	3
	+550°C/10 Hr (BAT)	Poor	10
	+607°C/10 Hr (BBF)	OK	20
	+705°C/10 Hr (TT)	OK	ND
	EPRI-LOT 2 (MAL)	Poor	1
	EPRI-Lot 1A (MAH)	OK	10
N08800	CANDU	NA	No Cracking Observed

NOTES: NA - not applicable ND - not determined

ABBREVIATIONS:

BAU	Bruce A U-bend
BAT	Bruce A Tubesheet
BBF	Bruce B Full-vessel
TT	Thermally Treated
MAH	Mill Annealed, High Temperature
MAL	Mill Annealed, Low Temperature

Corrosion Fatigue of Steam Generator Tubing Alloys

Corrosion fatigue cracking has not been an extensive problem for alloy N06600 steam generator tubing; however, the incidence of documented corrosion fatigue failures is rising. Failures due to this mechanism have occurred at:

> Oconee, a B&W once-through unit operated by Duke Power Co.;
> Ontario Hydro's Bruce NGS 'A',

and more recently at

> North Anna, a Westinghouse unit operated by Virginia Power Co., and Indian Point 3, a Westinghouse unit operated by the Power Authority of the State of New York.

The extent of environmental contribution in these failures is unknown. There are no known incidences of corrosion fatigue cracking of N08800 in steam generator service.

Since a synergistic stress-corrosion/corrosion-fatigue mechanism was believed responsible for the Bruce NGS failures, a project was initiated in 1988 to investigate the high cycle corrosion fatigue behaviour of N06600 and N08800 tubing of CANDU manufacture under conditions relevant to CANDU steam generator operation.

The fatigue response of CANDU N06600 and N08800 tubing is being determined over a range of loading and chemistry conditions encompassing those occurring in service. In order to make efficient use of limited resources, an orthogonal experimental design is employed.

High cycle fatigue is often simulated in laboratory investigations by testing smooth or notched specimens under cyclic loads. In this program, a U-bend tubing specimen geometry was chosen because it offers advantages in containing an environment, as well as in the loads required to produce high stress levels and the ability to accommodate a mean stress.

A significant portion of the 1988 period was spent in the development, commissioning, and improvement of a U-bend flexure test rig. The first series of experiments at variable stress amplitudes were conducted in laboratory air at room temperature (~21°C), with a mean stress of 200 MPa and cycle life of $10^{6.5}$.

A revision was made to the original test matrix to accommodate additional variables affecting fatigue behaviour, and testing in air will be continued in 1989. Environmental tests will be performed in 1989 under various conditions of heat-treatment, frequency, mean stress, pH, anionic constituents, and number of cycles. These are considered as experimental input parameters in an orthogonal design and each will be examined at two levels.

Heat Exchanger Corrosion

Ontario Hydro's nuclear plants have experienced several heat exchanger tube bundle failures due to pitting from the cooling lake water side. Although various alloys have been involved, all failures have taken a similar form involving crevice corrosion beneath adherent sand, clay, and carbonate mineral deposits. Alloy N08800 moderator heat exchangers have been particularly prone to leakage as a result of pitting corrosion. To investigate ways of eliminating corrosion of moderator heat exchangers a number of studies have been initiated which include field and laboratory experiments. The field studies are directed towards the generation of corrosion information under simulated service conditions. Two model heat exchangers are currently in operation and are situated at Pickering and Darlington NGS. The laboratory programs include electrochemical, immersion experiments, and microbiological studies.

In 1988 most of the effort on the heat exchanger program was expended on the analysis of tubes from the Darlington and Pickering test rig systems. Tubes were periodically removed from the Pickering facility in order to glean some information on the sequence of events which lead to tube fouling and eventually to pitting.
The principal results of the examination were:

a. Fouling is initiated with the formation of a biofilm, which likely consists of extracellular materials and bacteria.

b. Biofilm attachment appears to be followed by the deposition of calcareous material. Deposition likely starts on the sediment particles which have become entrapped in the organic layer.

c. The final and ongoing stages are probably a combination of the above together with sediment build-up. During the examination it was also discovered that shallow pits (<10 μ) had developed beneath the fully formed deposit. Pits were only observed on N08800 tubes, and had formed during less than eighteen months of exposure.

A heat exchanger bundle was also removed from the Darlington rig during 1988. The bundle had been in service for approximately one year. A thorough examination of the tubes which consisted of detailed surface analyses and metallurgy revealed similar pitting corrosion of the N08800 tubes.

None of the other alloys, including the current replacement materials, N08825 and N08028, were attacked. This discovery led to all of the remaining N08800 heat exchanger bundles at Darlington NGS being replaced with alloy N08028.

As it is possible that bacteria, specifically sulphate reducing species, play a role in the heat exchanger pitting process, a preliminary study to investigate this aspect of corrosion was started. This work involved

a collaborative effort between the Biology and Corrosion and Tritium Technology Sections. Coupons of alloy N08800 were exposed to culture medium inoculated with bacteria. After an exposure period of five months, it was established using surface analytical techniques that sulphate reducing bacteria are capable of attaching themselves to the surface of alloy N08800 and that they can change the chemistry of the protective oxide.

In addition to the moderator heat exchanger alloy investigations, some attention was also given to the PNGS-B Monel 400 shutdown heat exchangers. PNGS-B and PNGS-A tubes were examined with using a variety of surface analysis techniques. The PNGS-B tubes had failed by pitting corrosion after less than six months service, whereas the same alloy had been in operation for 13 years at PNGS-A. These analyses indicated that sulphur, present as an impurity is highly segregated in the 'B; material, while in the 'A' material it is far more uniformly distributed. Based on these observations, it is hypothesized that the pitting at PNGS-B is the result of an anode/cathode surface area phenomenon.

Work planned in the heat exchanger area for 1989 includes the removal and examination of more tubes which have been exposed to the heat exchanger test rig environment for longer than those previously removed. The emphasis of the work will be on the examination of undisturbed pits in order to better understand mechanism(s) of pitting and to establish whether alloys other than N08800 are showing indications of localized attack. It is hoped that this work will also provide pit propagation data and additional information regarding bacterial colonization in the vicinity of the pits.

Electrochemical studies on the influence of sulphate reducing bacteria on the corrosion of heat exchanger alloys as fabricated and following various surface protective treatments, are planned for the coming year. The programs also include potentiokinetic and electrochemical noise investigations.

Corrosion Engineering

In addition to the well defined corrosion programs aimed at obtaining predictive data, work which requires immediate attention and which can be done because of the existence of established data and expertise is also performed. Tasks in this category include thermal plant scale analyses, cathodic protection system design, domestic hot water tank coating evaluations, and nuclear waste container corrosion.

During 1988 numerous requests were made for information on the oxide morphology and hence health of thermal plant heat exchangers. Waterside and fireside oxide scales were examined and reported on for Lambton GS, Lakeview GS, Nanticoke GS, and Brandon GS (Manitoba Hydro). Thermal plant cathodic protection has also been a major area of activity during the past year. Impressed current systems have been designed to protect underground piping at Lennox GS and Nanticoke GS.

Hot water tank corrosion continues to be a major work area. Recommendations on the types of sacrificial anodes to be used for different water chemistries were made. The quality of the glass coating applied to the inside of hot water tanks was also evaluated. Several vendors supplied tanks to Hydro for examination and evaluation.

It is envisaged that work of a similar nature to the above, will continue to be requested during the coming year.

One final program which also comes under the corrosion engineering classification is nuclear waste container corrosion. Copper, because of its nobility to most chemicals, is being considered as a container material for future disposal of irradiated nuclear fuels in hard rock formations. In 1988, work on the effects of radiolysis on the corrosion of copper in bentonite was completed. The results indicated that irradiation caused an increase in the corrosion rate at 75°C and a decrease at 150°C. Corrosion was generally in the form of micropits. These results together with those obtained from earlier saline and sulphide environments provide estimates on the upper bounds of corrosion in the engineered disposal vault. The plan for 1989 is to further investigate the possibility of localized corrosion of nuclear waste container materials.

TRITIUM TECHNOLOGY PROGRAM

Tritium Storage and Scavenging

Studies in the field of getters spans eight years. Two distinct areas of activity have developed: tritium storage and tritium scavenging. In the former case metal getters, in particular uranium, have been used as a safe tritium storage medium. In the latter case metal getters are used to remove trace quantities of tritium from inert gas streams.

Tritium storage beds utilize uranium powder as the storage medium. Hydrogen gas is converted into a uranium hydride when brought in contact with clean raw uranium powder. Elevating the uranium hydride temperature to approximately 400°C releases the stored hydrogen as a gas. Several types of storage beds have been designed with a broad range of storage capacities. Five hundred kilocuries capacity beds, developed at Research are being pressed into service at Darlington TRF. Studies to replace uranium with other, perhaps more attractive, getter materials are underway. Zirconium-cobalt shows potential as an alternate storage medium.

Zirconium alloy getters developed by SAES have been extensively tested to determine the ability of these metal getters to remove tritium from nitrogen streams at the parts per billion level. The performance depends on flow rate, bed inventory, operating temperature, and impurity content in the stream. A uranium scavenger bed system has been designed for the tritium laboratory under construction at KfK Karlsruhe, a nuclear research facility in West Germany. Zr-Fe alloy getters also

appear attractive for glovebox cleanup systems. Nitrogen gas flushes the internal volume of a glovebox and passes the stream over a scavenger bed. Tritium which has escaped from process loops within the box is entrained in the stream and captured by the getter bed. Detritiation factors as high as 30,000 in a single pass have been measured.

Tritium Interaction With Materials

Investigation of permeation phenomena in metals spans 5 years. Studies have focused on atomic hydrogen permeation through metal membranes and bilayer metal membranes. A broad range of operating pressures have been covered. At low pressures, the permeation rate is limited by recombination at the surface while at higher pressures, the permeation is limited by bulk properties of the metal. Atomic hydrogen has been generated by contact dissociation on hot surfaces and by radio frequency discharges.

Several applications which rely on atomic hydrogen permeation at low pressures through membranes have been identified and are under investigation. A hydrogen monitor to measure atomic hydrogen fluxes in tokamaks has been developed and tested on the tokamak TEXTOR in Julich West Germany. A permeation pump developed at Research is in the final stages of construction. This device boasts compression ratios of 1000. With no moving parts, this device is particularly suited for tritium service. A tritium monitor which relies on hydrogen permeation is also under development. Fusion reactor exhaust streams are a mixture of deuterium, tritium, and a few percent impurities. A novel exhaust cleanup system which uses asymmetric permeation through a bilayer membrane and a ratio frequency source is under development.

Tritium Handling

Process equipment for tritium service must take into account several factors: leak tightness, cleanliness, ruggedness, and resistance to degradation due to low energy beta radiation. These requirements dictate a blending of three technologies: high vacuum, pressure vessel and radiation technology. A database which can assist neophyte tritium users has been under development for several years. This database which relies heavily on in-house assessments includes information on both techniques and instrumentation. Several tritium compatible components have also been developed in-house. In addition several manufactured devices have been tested and modified for tritium service.

The tritium technology database has found utility in several areas: technical support of the TRF, advisory support to CFFTP and NBV and in the construction and operation of the Research tritium laboratory.

Tritium Technology Work Program for 1989

The TT group has been the major contributor to the design and management of the new Divisional Tritium Laboratory at the Research Division. This group commissioned the laboratory during 1987 and 1988

and is responsible for day to day operation of the facility. This operation, during the past year has emphasized a few shortcomings in our tritium handling philosophy.

Within the tritium laboratory, the waste metal storage cabinet bulges with mildly contaminated components. These components can not be reused directly without decontamination. Since the decontamination process is time consuming, components tend to remain forgotten within the cabinet. At TRF, tritium concentrations within the process loops are substantially higher and the need for recycling or disposing of tritiated metal components is more acute.

The leak tightness of tritium process loops require verification with a helium leak detector. All leak detectors currently use a mechanical rotary vane oil pump to provide the rough vacuum necessary during the leak testing operation. During leak detection of mildly tritiated systems, volatile tritium is collected and concentrated in the mechanical pump oil. This tritiated oil represents several hazards. Oil changes result in a chronic emission of tritiated oil vapour. Evacuation of air from a non-tritiated system can lead to the emission of tritiated water vapour leached from the oil. During routine operation of the pump, tritiated oil vapours condense on surfaces within the pump and can slowly diffuse to the external surfaces. For these reasons, the leak detector represents a major source of contamination within the Research Division Tritium Laboratory.

Tritium can be viewed as a low energy density source. One device which exploits this fact is the tritium light. A glass tube coated internally with a scintillant and filled with tritium gas will emit light. This application suffers from two disadvantages: low light output and the potential for accidental release of tritium gas. An alternative approach which minimizes both drawbacks is the use of tritides. In this approach, tritium is stored on a thin metal getter film as a tritide.

Work efforts have begun in 1989 to address several concerns including those discussed above. These are listed in point form to provide the reader with a bird's eye view of the activity planned for TT during 1989.

- Technical support of TRF, CFFTP, and NBV. This includes the testing on components for TRF, permeation tests for the University of Rochester, conditioning uranium storage beds for use in tritium facilities at Darlington, the University of Rochester, Karlsruhe, and in Italy.

- Development of a metal decontamination center.

- Development of an oil free helium leak detector, responsive tritium process monitors, a glovebox cleanup system.

- Development of a reactor exhaust treatment system for fusion reactors.

- Development of devices which rely on the power produced by tritium decay.

- Improvement of tritium storage and scavenger beds.

ACKNOWLEDGMENTS

The progress described in this report is the result of the dedicated and hard work of all members of the section. The work program is large and each individual has been involved in maintaining our longer term core research program, while at the same time contributing to many shorter term, but equally high priority projects. These individual contributions are gratefully acknowledged.

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PCL:km

TABLE 1

CORROSION AND TRITIUM TECHNOLOGY STAFF
AS OF YEAR END 1988

Dr. P.C. Lichtenberger	(Phil)	Supervising Scientist

a) *Corrosion Group*

Dr. B.D. Warr	(Brian)	Scientist
Dr. A.V. Manolescu	(Angela)	Engineer (on rotation)
Mr. P.J. King	(Peter)	Engineer
Mr. A.M. Brennenstuhl	(Alex)	Engineer
Dr. K.W. Lam	(Kim)	Engineer
Dr. G.I. Ogundele	(Gabriel)	Engineer (temporary)
Dr. M.B. Elmoselhi	(Mohammad)	Engineer (temporary)
Mr. A.C. Headon	(Al)	Senior Technologist
Mr. J.W. Mummenhoff	(Juergen)	Technician
Mr. E.M. Rasile	(Elvio)	Technician
Mr. S.W. Borda	(Steve)	Technician
Mr. L. Grant	(Laniel)	Technician
Ms. B. Guest	(Bonnie)	Technician
Mr. L. Chee	(Lloyd)	Technician
Mr. J. DeLuca	(Jerry)	Technician (temporary)

b) *Tritium Technology Group*

Dr. W.T. Shmayda	(Walter)	Scientist
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Mr. A.G. Heics	(Andy)	Engineer
Mr. N.P. Kherani	(Nazir)	Engineer
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Mr. K.D. Geiger	(Ken)	Technologist
Mr. B.L. Fishbein	(Bernie)	Technologist
Mr. M.J. Dudycz	(Mike)	Technologist
Mr. R.J. Opatril	(Rad)	Technician
Mr. M.D. Hooper	(Mark)	Technician

REPORTS ISSUED

DATE	CATEGORY	REPORT NO	JOB NO	FILE NO	TITLE AND AUTHOR(S)
February 3/88	B	M88-2-K	82-119-50250	827.48	1987 Bruce 'A' Cold Water Intake Structure Cathodic Protection Survey and Examination of Corrosion Coupons - Visual Examination of Bruce 'B' CW Intake Structure - A.C. Headon
February 16/88	B	M88-8-K	82-108-40151	827.22	Trip Report - Japan Power Reactor & Nuclear Fuels Development Corporation, Hitachi, Japan Atomic Energy Research Establishment, November 16-21/87 - B.D. Warr
February 24/88	B	M88-10-K	82-10740151	827.22	Asian Pacific Corrosion Conference Melbourne, Autralia and Visit to the State Electricity Commission of Victoria (SECV) Research Labs - November 16-26/88 - B.D. Warr
March 12/88	B	M88-19-CON	82-119-40150	827.28	Recovery of Tritium from ^{3}H Light Sources - Concept - W.T. Shmayda and N. Kherani
March 29/88	B	M88-20-K	82-137-40151	827.22	Analysis of Corrosion and Deuterium Uptake in Operating Reactor Pressure Tubes - Status Report on Pickering 3L09 and Pickering 4 Scrapings - B.D. Warr
July 8/88	B	M88-54-K	82-139-401	827.24	Irradiated Nuclear Fuel Disposal Container Research Program - K. Lam
July 25/88	B	M88-42-K	82-157-50451	827.48	Heat Exchanger Tubing Localized Corrosion-N08800 and N08028 Crevice Corrosion Probability and Rates - K. Lam
Aug 2/88	B	M88-50-P	82-799-003501	827.4	Analysis of Waterside Surface of a Boiler Tube Sample ... Hydro - A.V. Manolescu

REPORTS ISSUED

DATE	CATEGORY	REPORT NO	JOB NO	FILE NO	TITLE AND AUTHOR(S)
Aug 16/88	B	M88-60-K	82-204-40152	827.21	Corrosion Fatigue and Stress Corrosion Cracking of Steam Generator Tubing Alloys N06600 & N08800 - G.I. Ogundele
Sept 7/88	B	M88-64-K	82-214-40151	827.4	1988 Corrosion Inspection at the Mothballed Bruce Heavy Water Plant - A.C. Headon
Nov 18/88	B	M88-91-H	82-055-004	827.211	Pickering NGS 'B' Irradiated Fuel Bay Corrosion Monitoring Rods, Inspection - A.C. Headon
Nov 25/88	B	M88-67-K	82-116-552	827.48	Isothermal Exposure Testing of Heat Exchanger Tubing Alloys - P.J. King
Dec 16/88	B	M88-92-K	82-505-052	827.48	An Investigation of Artificial Crevice Formers for Corrosion Studies - P.J. King

CONFERENCE/SEMINARS ATTENDED

VISITS TO OUTSIDE ORGANIZATIONS

CORROSION AND TRITIUM TECHNOLOGY SECTION

DATE	ATTENDED BY	DESCRIPTION
January 11-15/88	A.B. Antoniazzi	Ontario Hydro Tritium Handling Course
January 24-26/88	A.B. Manolescu	WNRE - Meeting P3L09 Examined by OM and SEM
March 4/88	B.D. Warr	University of Western Ontario - SIMS Analysis
May 1-6/88	A.G. Heics	3rd Topical Meeting on Tritium Technology in Fission, Fusion and Isotopic Applications, Toronto
June 10/88	N.P. Kherani	Visiting and meeting at Tokamak de Varennes, Varennes, Quebec
June 19-24/88	B.D. Warr P.C. Lichtenberger	Zirconium in the Nuclear Industry, San Diego, CA
July 27/88	M.B. Elmoselhi	21st Annual Convention, International Metallographic Society, Toronto
Sept 4-9/88	N.P. Kherani	International Symposium on Metal Hydrogen Systems, Stuttgart, FRG
Sept 12-13/88	N.P. Kherani	Joint European Torus, Abingdon, England
Sept 19-23/88	W.T. Shmayda	Symposium on Fusion Technology: Utrecht; The Netherlands
Sept 19-23/88	W.T. Shmayda	Institut for Plamaphysik; KFA, Julich, West Germany
Sept 26-28/88	W.T. Shmayda	High Temperature Superconductive Material Technology Symposium, Toronto
Sept 15/88	A. Manolescu	

CONFERENCE/SEMINARS ATTENDED

VISITS TO OUTSIDE ORGANIZATIONS

CORROSION AND TRITIUM TECHNOLOGY SECTION

DATE	ATTENDED BY	DESCRIPTION
Oct 3-7/88	A.B. Antoniazzi	35th National Symposium of the American Vacuum Society
Oct 5-7/88	G.I. Ogundele	Canadian Region Eastern Conference, NACE, Toronto
Oct 9-13/88	A. Heics	8th Topical Meeting on the Technology of Fusion Energy, Salt Lake City, Utah
Nov 17-18/88	M.B. Elmoselhi/B.D. Warr	NRC (Vaccum Measurement and Workshop) and a Visit to AECL Labs at Chalk River

PRESENTATIONS/PUBLICATIONS

CORROSION AND TRITIUM TECHNOLOGY SECTION

DATE	AUTHORS	DESCRIPTION
January 13/88	A. Heics/W. Shmayda	OHRD Tritium Radiation Protection Course #481.1 - Tritium Handling Equipment
January 13/88	N.P. Kherani/W. Shmayda	OHRD Tritium Radiation Protection Course #481.1 - Tritium Interaction with Materials
February 10/88	K.W. Lam	Presented at the Workshop on Waste Container Corrosion - sponsored by AECL in Winnipeg
April 25/88	A. Heics	CFFTP Tritium Safe Handling Course
April 27/88	P.J. King	Presentation at McMaster University Corrosion Laboratory Colloquium "Corrosion in Nuclear Electric Power Generating Stations"
May 2/88	W.T. Shmayda N.P. Kherani J. Winter F. Waelbroeck	Plasma Surface Interactions in Controlled Fusion Devices, Julich, West Germany "Atomic Hydrogen Radial Flux Dependence on Plasma Parameters in TEXTOR
May 4/88	A. Heics	Tritium Compatible Equipment, Toronto - 3rd Topical Tritium Technology in Fission, Fusion and Isotopic Applications Conference. Presentation on "Ontario Hydro Research Division Tritium Laboratory: Design and Operating Experience".
June 15/88	P.C. Lichtenberger	Hydrogen Ingress Mechanisms in Zr-2.5 wt% Nb Pressure Tubes - An Overview of Some Recent Progress, Proceedings of the 28th Annual CNA/CNS Conference, Winnipeg, Manitoba

PRESENTATIONS/PUBLICATIONS

CORROSION AND TRITIUM TECHNOLOGY SECTION

DATE	AUTHORS	DESCRIPTION
Sept/88	M.B. Elmoselhi/ C.A. Ward	"The rate-limiting step in the kinetics of H_2 adsorption on Ni(100)". Presented at the International Symposium on Metal-Hydrogen Systems, Stuttgart, FRG.
Sept/88	M.B. Elmoselhi/ C.A. Ward	"The coverage dependence of the heat of adsorption and the predicted wave length of surface luminescence". Surface Science 203 (1988) 463-488.
Sept 4-9/88	N.P. Kherani W.T. Shmayda A.G. Heics	"Enhancing the rate of hydriding in uranium beds". Presented at the International Symposium on Metal-Hydrogen Systems, Stuttgart, FRG.
Oct 3/88	A.G. Heics/W.T. Shmayda	CFFTP Tritium Safe Handling Course - "Tritium Compatible Equipment"
Oct 3/88	N.P. Kherani/ W.T. Shmayda	CFFTP Tritium Safe Handling Course - "Tritium Interactions with Materials"
Oct 13/88	A.G. Heics/W.T. Shmayda N.P. Kherani	Comparison of Uranium and Zirconium Cobalt for Tritium Storage. Presented at the 8th Topical on the Technology of Fusion Energy, Salt Lake City, Utah

VISITORS TO RESEARCH DIVISION

CORROSION AND TRITIUM TECHNOLOGY SECTION

DATE	CONTACT	VISITOR AND ORGANIZATION	PURPOSE
March 2/88	A.V. Manolescu	Dr. B. Hoeking, WNRE	Meeting: Compositional Analysis of PT Sample (ESCA)
March 9/88	B.D. Warr	V. Urbanic, CRNL	Meeting: Paper for Conference - Zirconium in the Nuclear Industry
May/88	B.D. Warr	B. Johnson, Battelle	Discuss corrosion and deuterium ingress in zirconium alloys.
May 6/88	W.T. Shmayda	Participants of the CFFTP Tritium Safe Handling Course	Visiting tritium laboratory and hydrogen laboratories.
May 12/88	N.P. Kherani	M. Glugla & F. Willin, KFK, West Germany	Visiting tritium laboratory
June 20/88	P.J. King	A. McIlree, EPRI and R.L. Tapping, CRNL	Review and discussion of steam generator tubing stress corrosion work.
July 13/88	W.T. Shmayda	Dr. C. Daughney, Fusion Canada	To discuss calibration program at TEXTOR.
Aug 8/88	W.T. Shmayda	Drs. Ide, Fukui, Enoida, JAREI	To discuss research in tritium technology.

VISITORS TO RESEARCH DIVISION

CORROSION AND TRITIUM TECHNOLOGY SECTION

DATE	CONTACT	VISITOR AND ORGANIZATION	PURPOSE
Oct 7/88	W.T. Shmayda	A. Bell, JET European Torus (JET), JK	Discussion of tritium material interactions.
Oct 31/88	W.T. Shmayda	Y. Matsuda, Y. Narusi, Japan Atomic Energy Research Institute	Discussion of common research activities.
Dec 12/88	A.G. Heics	J. Miller, R. Johnson, CRNL	Tour of OHRD Tritium Laboratory